THE THOUSAND AVIATORS - A THIRTY-YEAR FOLLOW-UP

by

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SUMMARY

The "Thousand Aviator" project is a longitudinal study with the emphasis primarily on defining new physical standards for aviators and secondarily on an epidemiological study of aging. The present report is limited to a discussion of the electrocardiographic and blood pressure findings. Longitudinal changes in the resting electrocardiograms have shown that those individuals with a decrease in QRS amplitude and a leftward movement of the QRS vector appear to have a tendency to develop coronary artery disease. However, further follow-up will be needed to validate these findings.

Work electrocardiograms do not yet have the degree of reliability necessary for an aviation population.

Some of the men in the group have shown a consistent rise in blood pressure, apparently related to weight gain and parental longevity. Otherwise there are no means by which the blood pressure pattern of an aging individual can be predicted.

The study has shown the need for a periodic reappraisal of aviation physical standards.

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Introduction to the Study

This investigation, commonly referred to as the "Thousand Aviator" study, began in Pensacola, Florida in July 1940 as an attempt to identify and validate tests which would have predictive value in terms of the success or failure of candidates in the Navy flight training program. The initial studies consisted of a large number of psychological and physiological tests, given to over a thousand flight students and a small number of flight instructors over a period of about ten months. Some of the psychological and psychomotor test results had predictive value in terms of passing or failing flight training, which led to their further exploitation both within and without the Pensacola command.

The predictive value of the physiological test items in terms of success in training was practically nil, and in the exigencies of World War II this part of the study was almost forgotten. After the war, however, the value of a prospective study, emphasizing serial changes as a function of increasing age, was recognized. Thus, although the "Thousand Aviator" project was not designed originally as a longitudinal study, subsequent surveys, done in 1952, 1958, 1963, and 1969, have given it this orientation, and emphasis has been given primarily to its value in defining new physical standards for aviators and secondarily as an epidemiological study of aging. The participants were volunteers, and the agreement has been strictly adhered to that the findings would not be made a part of their service record.

The time frame makes it necessary to limit the scope of this report; thus the discussion will center on the electrocardiographic and blood pressure findings. It should be pointed out that this is essentially a progress report inasmuch as we are still examining the members of the group.

Electrocardiographic Findings

Standards

At the time this study was started, electrocardiograms were not routinely obtained while examining individuals entering the military service, and little had been done to establish standards for interpretation of the test. It was not until 1960 that the United States Navy began to do routine electrocardiograms on students entering the flight training program, and it was 1964 before guidelines were laid down in the Manual of the Medical Department relative to electrocardiographic abnormalities. Even today we are not certain as to the significance of some of the findings, notably the Wolff-Parkinson-White syndrome and the atrioventricular blocks. Recently there has been considerable discussion relative to the significance of occasional premature ventricular contractions of unifocal origin. There are some who feel these ectopic beats have pathological significance. It is our opinion, based on the long observation of our group, that they have little or no significance in the otherwise healthy individual.

Resting Electrocardiograms

Ninety of the men were taken into flight training with electrocardiographic findings we would consider as frank or borderline abnormalities today. These included the

Wolff-Parkinson-White syndrome (2 cases), right bundle branch block (2 cases), left bundle branch block (1 case), significant left axis deviation (8 cases), first degree atrioventricular block (11 cases), generalized lowering of T waves (2 cases), and many borderline or suspicious changes. It is interesting to note that, by 1952, fifty-nine records previously interpreted as abnormal had reverted to normal; of those individuals with persistence of the abnormalities none had developed clinically apparent heart disease up to the time of the 1963-1965 examinations.

The predictive value of the single resting electrocardiogram is limited. However, longitudinally there have been changes which may ultimately prove to be of value as predictors of disease. There has been a progressive leftward movement of the QRS vector and a decrease in QRS amplitude as the men have aged. These changes have taken place during that period when pathological studies indicate that coronary arteriosclerosis is increasing at the greatest pace. These observations and the correlation between vector orientation, QRS amplitude, and the presence of coronary heart disease in populations with widely differing prevalence of disease suggest that these changes might be due to clinically silent arteriosclerosis and thus afford a clue to the presence of coronary artery disease. Those individuals with the greatest decrease in QRS amplitude in the earlier stages of the study and those with a greater leftward movement of the QRS vector appear to be showing a tendency to develop cardiac disease. Coronary arteriosclerosis is so unpredictable in this age group, however, that we shall have to wait until all of the data are in, including more individuals with

coronary artery disease to assess these factors completely. Interval changes in T-wave amplitude have not been related to the development of disease, which is somewhat surprising in that T-wave amplitude is usually lower in patients with disease. The changes in amplitude have not correlated significantly with weight and blood pressure; the changes in QRS axis have correlated.

Work Electrocardiograms

We still do not have the means of predicting an acute incident. Even our severest stress testing may fail to give a clue to disease. An example of this is one of our study group who died recently. The man was 56 years old when seen six months prior to his death. On physical examination he was found to have a markedly enlarged prostate; otherwise all of our studies, including strenuous stress testing, were well within normal limits. Because of the enlarged prostate it was recommended that he consult a urologist; the latter recommended surgery. During surgery the man went into cardiac arrest and died a short while later. On autopsy he was found to have severe coronary sclerosis, with the coronary arteries showing only 20% of their normal lumina. Repeated reviews of his records have failed to reveal any evidence of this disease. Comparison of the electrocardiograms taken over the 29 years he had been followed does show the leftward movement of the QRS vector and the decrease in QRS amplitude. By the same token, we have individuals in the group who had abnormal exercise tests in 1963, who still show abnormal tests in 1970, yet have been completely asymptomatic and living full lives. This is not to say that we have not been able to diagnose disease but rather that we do not yet have the degree of reliability we would like to have, particularly in working with an aviation population.

Summary

The data are incomplete relative to the electrocardiograms, but it appears that some modification of the standards may be possible. Some of the abnormalities heretofore considered disqualifying may be of little significance as regards the useful life of the aviator. We are particularly concerned about that period during which the man is doing operational flying, or up to about 38 years of age.

Blood Pressure Findings

Physical Standards

In 1912, when the first aviation standards were published, there was no set standard for blood pressure. The instruction simply read "Any marked departure from normal blood pressures will be considered a cause for rejection." No values were given. In 1922 the blood pressure limits were established as 135 mm Hg systolic if under the age of 25 and 145 mm Hg systolic if over the age of 25; diastolic pressure could not exceed two-thirds the systolic pressure. In 1939 the standards which were applicable to the "Thousand Aviator" group were published: For flight candidates the limits were 135/90 mm Hg; for designated aviators under the age of 25 the limits were 140/95 mm Hg, and for those over 25 the limits were 150/95 mm Hg. In 1951 the standards for candidates were modified to 130/84 mm Hg and remained at that level until 1968 when the standards for candidates and for designated aviators under the age of 35 were changed to 139/89 mm Hg, for aviators between 35 and 45 years of age to 149/89 mm Hg, and for aviators over the age of 45 to 154/94 mm Hg. As can be seen,

the standards for candidates have been relaxed. There is good justification for this in the fact that in no one of the research group still on active duty at the time of the 1963-1965 examinations had symptomatic hypertension developed, even in those who were at the extreme upper limits of normal or who had lability of their pressure at the time of the 1940 examination.

Serial Changes

Several important aspects of longitudinal changes in blood pressure have been noted in this study. Although the mean level of blood pressure for the entire group has increased with age, it has not increased in every individual, and in fact, in most of the members there has been some random variation during the thirty years of follow-up. However, some of the men have shown a consistent rise in blood pressure as they have grown older, and the increase of mean pressure for the group reflects the increase in these individuals. Two factors are found to be associated with this increase: The subjects with increasing blood pressure have put on more weight as they have grown older, and they had short-lived parents.

The age at which parents died appeared to be significant in 1940, with minimal dependence on weight gain, whereas weight gain was of greater importance from 1952 to 1969. It is not surprising that weight gain was unimportant in 1940 because the men were physically fit at that time, with little excess weight. Those men with greater weight gain are even more likely to have high blood pressures if their parents died in middle age, but for those with a weight gain of 20 pounds or less, parental longevity is unimportant.

In addition to the fact that the blood pressure does not necessarily rise with age, it has been noted that individuals at the extremes of the distribution tend to maintain their relative position. Apropos of this, the data suggest that those individuals at the upper end of the distribution in 1940 have their pressure determined at an early age, possibly the result of some autoregulatory mechanism. Those men at the lower end of the distribution did not manifest consistent levels until 1952, after which everyone in the group maintained his relative rank in the distribution, especially those in the first and fifth quintiles. Parental longevity differs between these same quintiles. Responsibility for the difference in age at which fixed rank is attained may be an interplay of environmental and genetic factors subsequent to 1940.

Predictive Value of the Measurements

Except for the correlation of weight and parental longevity, there are no means by which the blood pressure pattern of an aging individual can be predicted. The cold pressor test and labile blood pressures were not significant predictors of future blood pressure levels in the "Thousand Aviator" group. Lability of blood pressure has been considered a prehypertensive state or an early phase of hypertension, yet the men in this group have shown little relationship between lability and mean level of pressure.

Summary

A significant factor in the vascular health of the individual may be his weight. There is a significant correlation between blood pressure and weight in the members of our group.

Conclusion

The "Thousand Aviator" study has shown the need for a periodic reappraisal of physical standards, both for initial entry into flight training and for the aging pilot. As a result of the thirty-year follow-up, it has been shown that some of our standards are too stringent and can be modified with benefit to the individual and to the effectiveness of the operational flying program. Moreover, it is cost effective. With the present high cost of the initial training and the inestimable value of the man's experience, particularly during the period of operational flying and to a significant degree thereafter, this is a not unimportant item.